**Activity: Rube Goldberg Meets Bingo to Solve Mole Calculations**

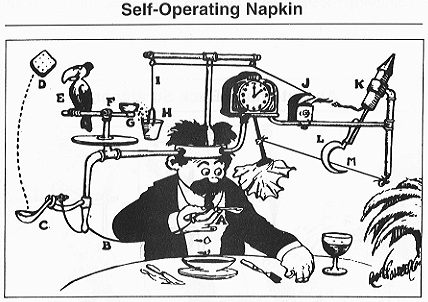
Course: SCH3U

Unit: Quantities in Chemical Reactions

Lesson: Review of Mole Calculation Questions

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| **BIG IDEAS**: | | **MATERIALS**: |
| The mole is a chemist’s unit of measurement and can be used to make predictions about chemical reactions | | Optional: Video camera  Optional: Bingo prizes |
| **MINISTRY EXPECTATIONS**: | |
| A1.11, A1.12, A1.13 Communicate ideas/plans using appropriate language and a variety of formats; use appropriate numeric models of representation and appropriate units of measurement; express calculations accurately and precisely using significant figures  D2.1, D2.3, D2.6 Use appropriate terminology; solve problems involving quantities in moles, number of particles, and atomic mass; Perform calculations involving percentage yield and limiting reagents | |
| **STUDENT LEARNING GOALS**: | | **APPENDICES** |
| 1. Students learn to develop **strategies** for solving calculation questions 2. Students apply calculation strategies properly using correct units and mathematics | | Appendix I: Rube Goldberg questions  Appendix II: Rube Goldberg graphic organizer  Appendix III: Mole Bingo cards  Appendix IV: Mole Bingo questions |
| **PRIOR KNOWLEDGE:** | |
| * Mole conversions using molar mass and Avogadro’s number * Calculations involving mole ratios and limiting reagents * Calculations using percent yield | |
| **PART** | **T/L STRATEGIES** | **ASSESSMENT** |
| ACTION  60 min. | **Rube Goldberg (30 min)** - Development of a **strategy** for solving calculation questions   * Students develop kinesthetic and visual cues for solving mole calculation questions * DI – Students solve questions individually and in groups, kinesthetically/visually/written   **Mole Bingo (30 min)** – Application of strategies to solve mole calculation questions   * Students apply the tools they developed using Rube Goldberg to practice mole calculation questions * Formative assessment for teacher | **Assessment FOR Learning** – This activity will allow teachers to assess students’ basic knowledge of complex mole calculation questions |

**Activity Overview & Teaching Notes**

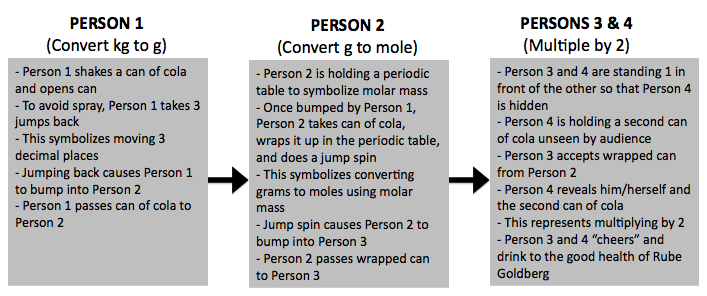
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* This is a **60-70 min activity** that is meant to serve as a content review for solving **mole calculations** (mole conversions, mole ratios, and limiting reagents) within the SCH3U *Quantities and Chemical Reactions* unit
* This unit contains many **multi-step calculation questions** that can be confusing for students who struggle to understand abstract mathematical concepts
* Coupling Rube Goldberg with Bingo helps students apply **analogies** and **visual/kinesthetic cues** to consolidate ideas and break large questions into smaller, more manageable portions
* This activity is most effective as a **cumulative activity** administered in the days leading up to a test or summative evaluation, however it could easily be tailored to address more specific concepts within the unit if desired
* This activity emphasizes students’ ability to **communicate** their ideas and addresses **two skill sets** that students must possess in order to master mole calculations:
* Development of a **strategy** for solving calculation questions
* See **Part A: Rube Goldberg (Appendix I-III)**
* Able to apply calculation strategies properly using correct units and mathematics
* See **Part B: Mole Bingo (Appendix IV-V)**

**Part A: Rube Goldberg – Developing strategies for solving mole calculation questions**

**TEACHER INSTRUCTIONS**

1. Model what it looks like to use Rube Goldberg to describe mole calculations (10 min)
   * **Show video:** OK GO music video “*This Too Shall Pass*”
     + <http://www.youtube.com/watch?v=qybUFnY7Y8w>
   * **Sample Question:** A typical can of cola contains 0.4 kg of sucrose, C12H22O11. Determine the number of moles of sucrose present in 2 cans of cola.
   * **Solution:** Figure out the steps needed to solve this problem and develop a creative Rube-Goldberg visualization of these steps
     + Convert kg to g
     + Convert g to mol using molar mass
     + Determine the number of moles in 2 can by multiplying by 2
     + Sample Rube Goldberg strategy:
2. Students develop their own Rube-Goldberg solutions (5 + 10 min)
   * Divide students into families/teams (6 people per group):
   * Give students a card containing a mole calculation question (**Appendix I**)
   * Students work together to determine the steps involved for solving their question
   * Students are allowed to have 10 minutes to design a 1-minute Rube Goldberg representation of their strategy (**Appendix II, III**)
3. Students perform their Rube-Goldberg solution to the class (5 groups = ~20 min)
   * Students record strategies of other groups in organizer (**Appendix II, III**)
   * **Optional**: Video student performances and post to class website or Moodle

APPENDIX I: Mole Calculation Questions

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| **Rube Goldberg Mole Calculation Question** | **Rube Goldberg Mole Calculation Question** |
| **Question 1:**  Hydrochloric acid reacts with sodium hydroxide to form water and sodium chloride. If 10 g of hydrochloric acid reacted with excess sodium hydroxide, how many kilograms of sodium chloride is produced? | **Question 2:**  What amount of hydrogen (in kg) is produced when 5.2 mol of ammonia decomposes? |
| **Rube Goldberg Mole Calculation Question** | **Rube Goldberg Mole Calculation Question** |
| **Question 3:**  A typical astronaut exhales 8.8 x 102 g of carbon dioxide daily. Determine the mass of lithium hydroxide (in mg) required to react with this mass of CO2 if the reaction proceeds as shown below:  CO2(g) + 2LiOH(s) → Li2CO3(aq) + 2H2O(l) | **Question 4:**  Use your knowledge of mole conversions to determine the number of atoms present in 60.5 kg of MgCl2. |
| **Rube Goldberg Mole Calculation Question** | **Rube Goldberg Mole Calculation Question** |
| **Question 5:**  Use your knowledge of mole conversions to determine the number of atoms present in 18.0 g of titanium(IV) chloride. | **Question 6:**  Methanol, CH3OH, can be made using a synthesis reaction involving carbon monoxide and hydrogen. Identify the limiting reagent if 9.80 g of carbon monoxide and 1.30 g of hydrogen are present. |

APPENDIX II: Rube Goldberg: Student Handout

**Instructions**

1. (In group of 6) Obtain a mole calculation question
2. (Individually) Read the question quietly to yourself and begin thinking about how you would begin to solve this mole calculation question. Write your ideas in the box below:

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|  |

1. (In group of 6) **Compare** your flow chart with those made by your peers.

* Considerations:
  + Converting between grams and kilograms
  + Converting between grams and moles
  + Using mole ratios to determine the amount of product or reactant needed
  + Converting to moles to determine limiting reagent
  + Convert to moles to determine empirical formula

Working together, **create a final flowchart** in the box below that combines everyone’s ideas for solving the given problem:

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1. (In groups) Now that you have written down your strategy, work together as a group to create a **1-min Rube Goldberg skit** that will be performed to the class. You will have 10 minutes to create your skit. Feel free to use any available classroom props. All members of the group must have a role in the skit.
2. (Individually). As you are watching other groups perform, record their strategies for solving calculation questions in the following graphic organizer.

|  |  |  |
| --- | --- | --- |
| **Type of question** | **Strategy for**  **solving problem** | **RG Memory Cues** |
| **Question 1:**  Hydrochloric acid reacts with sodium hydroxide to form water and sodium chloride. If 10 g of hydrochloric acid reacted with excess NaOH, how many kilograms of sodium chloride is produced? |  |  |
| **Question 2:**  What amount of hydrogen (in kg) is produced when 5.2 mol of ammonia decomposes? |  |  |
| **Question 3:**  A typical astronaut exhales 8.8 x 102 g of carbon dioxide daily. Determine the mass of lithium hydroxide (in mg) required to react with this mass of CO2 if the reaction proceeds as shown:  CO2(g) + 2LiOH(s)  → Li2CO3(aq) + 2H2O(l) |  |  |
| **Question 4:**  Use your knowledge of mole conversions to determine the number of atoms present in 60.5 kg of MgCl2. |  |  |
| **Question 5:**  Use your knowledge of mole conversions to determine the number of atoms present in 18.0 g of titanium(IV) chloride. |  |  |
| **Question 6:**  Methanol, CH3OH, can be made using a synthesis reaction involving carbon monoxide and hydrogen. Identify the limiting reagent if 9.80 g of CO and 1.30 g of H2 are present. |  |  |

APPENDIX III: Rube Goldberg: Teacher Handout

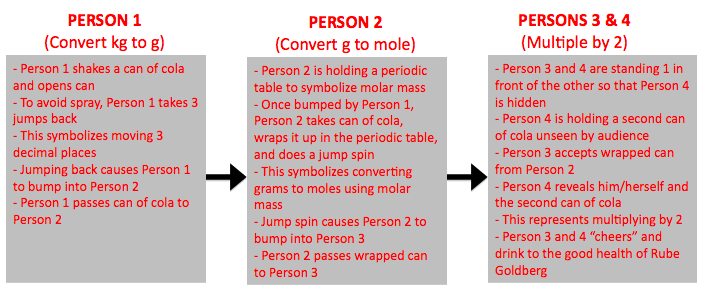
**Instructions**

1. (In group of 6) Obtain a mole calculation question
2. (Individually) Read the question quietly to yourself and begin thinking about how you would begin to solve this mole calculation question. Write your ideas in the box below:

|  |
| --- |
| * E.g. I have to start out by converting kg to g – multiply by 1000 * E.g. I know I have to use molar mass to convert from g to mol |

1. (In group of 6) **Compare** your flow chart with those made by your peers.

* Considerations:
  + Converting between grams and kilograms
  + Converting between grams and moles
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| **Type of question** | **Strategy for**  **solving problem** | **RG Memory Cues** |
| **Question 1:**  Hydrochloric acid reacts with sodium hydroxide to form water and sodium chloride. If 10 g of hydrochloric acid reacted with excess NaOH, how many kilograms of sodium chloride is produced? | 1. Write balanced equation 2. Convert HCl from g to mol 3. 1:1 mole ratio to determine mol of NaCl 4. Convert NaCl from mol to g 5. Convert g to kg | To be determined by students |
| **Question 2:**  What amount of hydrogen (in kg) is produced when 5.2 mol of ammonia decomposes? | 1. Write balanced equation (2NH3 → N2 + 3H­2) 2. 2:3 mole ratio to determine mol of H2 3. Convert H2 from mol to g 4. Convert g to kg |  |
| **Question 3:**  A typical astronaut exhales 8.8 x 102 g of carbon dioxide daily. Determine the mass of lithium hydroxide (in mg) required to react with this mass of CO2 if the reaction proceeds as shown:  CO2(g) + 2LiOH(s)  → Li2CO3(aq) + 2H2O(l) | 1. Convert CO2 from g to mol 2. 1:2 mole ratio to determine mol of LiOH 3. Convert LiOH from mol to g 4. Convert g to mg |  |
| **Question 4:**  Use your knowledge of mole conversions to determine the number of atoms present in 60.5 kg of MgCl2. | 1. Convert MgCl2 from kg to g 2. Convert MgCl2 from g to mol 3. Convert MgCl2 from mol to molecules 4. Convert MgCl2 from molecules to atoms |  |
| **Question 5:**  Use your knowledge of mole conversions to determine the number of atoms present in 18.0 g of titanium(IV) chloride. | 1. Convert TiCl4 from g to mol 2. Convert TiCl4 from mol to molecules 3. Convert TiCl4 from molecules to atoms |  |
| **Question 6:**  Methanol, CH3OH, can be made using a synthesis reaction involving carbon monoxide and hydrogen. Identify the limiting reagent if 9.80 g of CO and 1.30 g of H2 are present. | 1. Write balanced chemical equation (CO + 2H2 → CH3OH) 2. Convert CH3OH from g to mol 3. Convert H2 from g to mol 4. Perform ratio (H2 is limiting) |  |

**Part B: Mole Bingo – Students apply their Rube-Goldberg strategies during a game of Bingo**

**TEACHER INSTRUCTIONS**

1. Once students have review the strategies required for solving complex mole calculation questions, they can use
2. While **Part A: Rube Goldberg** was done in groups of 6 to allow for peer teaching, this bingo-style activity is played as individuals to ensure that all students are able to apply the knowledge they gained in Part A.
3. Distribute bingo cards (**Appendix IV**) to individuals within the class
4. Ask a student to close their eyes and randomly pick a question (**Appendix V**) from a beaker. It is useful to have these questions printed on overhead slides (or be typed up in PowerPoint) so that everyone can see the question

* Students will read out question out loud
* As a class, students will decide which of the 6 strategies will be used for solving the question
* Individually, students will work to solve the question
* Once they have calculated an answer, go through the solution on the blackboard or on the overhead
* Students will mark the answer on their Bingo sheet
* The aim of the game is to get “3 boxes in a row”, horizontally, vertically or diagonally

APPENDIX IV: Mole Bingo Cards

**MOLE BINGO**

1. Question will be drawn from beaker
2. Decide which one of the 6 Rube-Goldberg strategies is best for solving question
3. Use selected strategy to calculate the answer to question
4. Mark the square on the Bingo card that matches your answer
5. When you get three squares horizontally, vertically, or diagonally shout “MOLE BINGO” and collect your prize

|  |  |  |
| --- | --- | --- |
| M | O | L |
| 0.32 kg | 6.2 x 1024 atoms | P4 is limiting |
| 0.028 kg | Free space | 18.9% |
| 137.2 g | 6.9 x 1023 atoms | 1.7 x 1024 molecules |

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| M | O | L |
| 6.9 x 1023 atoms | 137.2 g | 1.7 x 1024 molecules |
| Free space | 18.9% | 0.028 kg |
| 6.2 x 1024 atoms | 0.32 kg | P4 is limiting |

APPENDIX V: Mole Bingo Calculation Questions

1. Hydrochloric acid reacts with sodium hydroxide to form water and sodium chloride. If 20 g of hydrochloric acid reacted with excess NaOH, how many kilograms of sodium chloride is produced?

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1. What amount of nitrogen (in kg) is produced when 2.6 mol of ammonia decomposes?

2NH3(g) → N2(g) + H2(g)

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1. Iron (III) oxide, aka rust, can be removed from iron by reacting it with hydrochloric acid to produce iron (III) chloride and water. What mass (in g) of hydrogen chloride is required to react with 1.00 x102g of rust.

Fe2O3(s) + 6HCl(aq) → 2FeCl3(aq) + 3H2O(l) p. 244 MH

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1. A scientist weights out 300g of NaCl. How many atoms are present?

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1. Use your knowledge of mole conversions to determine the number of atoms present in 23.0 g of NaOH.

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1. Phosphorus (P4) burns in pure oxygen to form tetraphosphorus decaoxide (P4O10­). If 1.00g of phosphorus is burned in a flask containing 13.824g of O2, determine the limiting reagent.

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1. Ammonia can be prepared by reacting nitrogen gas with hydrogen gas. Theoretically, 9.10g of ammonia should be obtained when 75 g of nitrogen reaction with excess hydrogen. When you perform the reaction, only 1.72 g are obtained. Calculate the percent yield.

N2(g) + H2(g) → 2NH3(g)

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1. A scientist weights out 500g of C6H12O6. How many molecules are present?

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**Teacher Answer Key:**

Question 1 = Rube Goldberg Strategy 1, Answer = 0.32 kg

Question 2 = Rube Goldberg Strategy 2, Answer = 0.028 kg

Question 3 = Rube Goldberg Strategy 3, Answer = 137.2 g

Question 4 = Rube Goldberg Strategy 4, Answer = 6.2 x 1024 atoms

Question 5 = Rube Goldberg Strategy 5, Answer = 6.9 x 1023 atoms

Question 6 = Rube Goldberg Strategy 6, Answer = P4 is limiting.

Question 7 = No Rube Goldberg Strategy, Answer = 18.9%

Question 8 = Rube Goldberg Strategy 4, Answer = 1.7 x 1024 molecules